EXCEPTIONAL ACCURACY

Optimize your water and environmental designs and lower your costs with FLOW-3D, the powerful computational fluid dynamics software for more accurate modeling. Expensive physical models are traditionally used to design and analyze hydraulic structures. FLOW-3D reduces costs and eliminates scaling issues associated with physical models by simulating the full-scale design.

FLOW-3D addresses a wide range of design problems in hydraulics engineering. Users can increase the capacity of existing infrastructure in hydropower plants, develop novel approaches to fish passages, design intakes that minimize head loss, develop improved forebay designs and tailrace flows, analyze scour and deposition and evaluate air entrainment.

FLOW-3D applies unique modeling principles that differentiate it from other software and enhance the accuracy of your results. 1-D and 2-D codes oversimplify important flow physics and do not provide a full analysis of currents and surfaces. FLOW-3D simulates the entire flow process so that these important details are not neglected.
GRAPHICAL USER INTERFACE

From model setup to simulation to detailed results analysis, **FLOW-3D** includes all the functionality you need in one simple-to-use application, driven by an intuitive graphical user interface. Users can easily set up a model and quickly mesh it through its graphical model builder, screen out model incompatibilities and configuration errors, and perform detailed analysis through extensive post-processing capabilities.

“FLOW-3D is a powerful tool for solving complex hydraulic issues related to planning, design and operation of our hydraulic system, as well as associated environmental studies. I am also impressed with Flow Science’s customer support and product development.”

Kevin Sydor, M.Sc., P.Eng.
Senior Hydrotechnical Studies Engineer, Manitoba Hydro
MESHING

FLOW-3D uses an approach to gridding that combines the advantages of simple rectangular grids with the flexibility of deformed, body-fitted grids. Fixed grids of rectangular control elements are simple to generate and possess many desirable properties (e.g., improved accuracy, smaller demands on memory, and simpler numerical approximations). The approach is referred to as “free-gridding” because grids or geometry can be freely changed, each independent of the other. This feature eliminates the tedious task of generating body-fitted or finite-element grids.

Advanced features such as conforming meshes make it possible to have highly-refined grids only in relevant regions of the computational domain. Using this feature it is possible to generate high-accuracy meshes around thin components and flow features while optimizing speed and memory with coarser grids in the surrounding regions.
A unique feature of FLOW-3D is the FAVOR™ (Fractional Area/Volume Representation) method, which permits true representation of complex geometry in a simple Cartesian mesh. As a result, FLOW-3D can be used to simulate flow in complex hydraulics structures accurately and efficiently.

TruVOF, FLOW-3D’s method for modeling fluids goes beyond the traditional Volume of Fluid (VOF) techniques to achieve the most accurate tracking of fluid surfaces to capture waves and hydraulic jumps.
POST-PROCESSING WITH FLOWSIGHT™

FlowSight is a state-of-the-art post-processing tool based on the industry leading Ensight, which has been highly customized for FLOW-3D.

Its capabilities include:

- Multiple iso-surfaces
- 2D clips with FAVOR™ geometry
- Animated streamlines
- Multiple viewpoints of simulation results
- Simultaneous view of FSI and fluid flow results
- Extensive annotation capabilities
- Read/plot data from external sources
- Interactive queries
- Texture mapping
- 3D stereo and head tracking
- Moving viewpoints
- Volume rendering
- Flipbook
- Portable Results
MODELING CAPABILITIES

Air Entrainment

Air Entrainment may help sustain growth of microorganisms and cause detrimental downstream bulking and overtopping structures. FLOW-3D’s Air Entrainment model determines quantities of air entrained and its volumetric bulking effects.

Hybrid Shallow Water/3D Flow

FLOW-3D simulates flow around 3D structures within a shallow water environment, such as bridges, drilling rigs at sea and dams in large reservoirs. The model combines shallow water and full 3D flow models in one simulation, enabling users to capture key flow details and model large domains efficiently.

Moving Objects

Engineers often need to model flows that include moving solid components. With FLOW-3D, the motion of these objects can be fully coupled or coupled with constraints making it possible improve a design quickly and reliably.

Sediment Scour

Scour and deposition is an important consideration in the design of bridges, dams and reservoirs. The Sediment Scour model in FLOW-3D enables users to study the erosion and deposition of multiple sediments including bedload transport caused by complex flow patterns.

Stress Modeling

FLOW-3D’s Fluid Structure Interaction model enables users to predict stresses and deformations of solids under load by using a coupled solution between fluids and solids. Stress prediction provides valuable information to determine whether a design meets safety criteria or may ultimately fail.
APPLICATIONS

Catastrophic Events

FLOW-3D can simulate a variety of catastrophic events including dam breaks, avalanches, tsunamis and flooding.

Dams and Spillways

Dam and spillway safety is an essential component in the design process. FLOW-3D enables engineers to predict flow rates at Probable Maximum Flood conditions and determine cavitating regions and pressure loading on gates.

Fish Passages

Fish passages are an important environmental component of many hydraulic structures. FLOW-3D enables engineers and designers to accurately analyze existing and new designs to determine whether a fish species will use the passage under various flow scenarios.

Municipal

FLOW-3D is used in the water and wastewater industry to design and analyze contact tanks, control structures, combined sewer and stormwater sewer overflow facilities, pump and lift stations, treatment plant headworks and filtration systems.

River Hydraulics

FLOW-3D is widely used to address complex river dynamics and to predict fluvial behavior. In addition to solving free-surface flow patterns, FLOW-3D includes a broad selection of powerful physics packages that address most river management problems.
FEATURES

Water & Environmental Models
- Sediment transport and scour
- Scour potential
- Air entrainment
- Scalar transport
- Screens
- Cavitation
- Melting, evaporation, freezing
- Wall roughness
- Vapor bubbles
- Chemical reactions
- Mass/momentum/energy sources
- Molecular & turbulent diffusion
- Particle/tracers
- Fluid structure interaction

Results Analysis
- Automatic or custom graph requests
- Interactive OpenGl-based graphics (grid overlay optional)
- Color or B/W vector, contour, 3D surface & particle plots
- Moving history & probe data
- Probe data for fluid-structure interaction
- Force & moment computations
- Animation output
- PostScript, JPEG & Bitmap output
- Streamlines, streaklines & flow ribbons
- STL geometry viewer

Two-Phase & Two-Component Models
- Liquid/liquid & gas/liquid interfaces
- Two-fluid mixtures
- Compressible fluid with a dispersed incompressible component
- Diff-flux
- Two-component, vapor/non-condensable gases
- Phase transformations for gas/liquid & liquid-solid
- Adiabatic bubbles
- Bubbles with phase change
- Continuum fluid with discrete particles

Discrete Particle Models
- Massless marker particles
- Mass particles of variable size/mass
- Linear & quadratic fluid-dynamic drag
- Monte-Carlo diffusion
- Particle-fluid momentum coupling
- Coefficient of restitution or sticky particles
- Paint or volumetric particle sources
- Electrically-charged particles
- Probe particles

Turbulence Models
- Prandtl mixing length
- One-equation transport
- Two-equation k-ε model
- Two-equation k-x model
- RNG model
- Large eddy simulation

Porous Media Models
- Variable porosity
- Directional porosity
- General flow losses (linear & quadratic)
- Capillary pressure
- Unsaturated flow
- Porous baffles & filters with linear & quadratic flow losses

Shallow Flow Models
- Shallow water model
- General topography
- Wind shear
- Surface roughness effects
- Geophysical scale flows

Fluid Structure Interaction
- General moving objects model with 6 DOF-prescribed and/or fully-coupled motion
- Rotating/spinning objects
- Collision model
- Moving assemblies
- Tethered moving objects
- Flexing membranes and walls
- Porosity
- Finite element based elastic-plastic deformation

Chemistry Models
- Stiff equation solver for chemical rate equations
- Stationary or advected species

Mesching & Geometry
- Structured finite difference/control volume meshes for fluid and thermal solutions
- Finite element meshes for structural analysis
- Multi-block gridding with nested, linked, overlapping and conforming mesh blocks
- Fractional areas/volumes (FAVORM) for efficient & accurate geometry definition
- Basic Solids Modeler
- Import CAD data
- Import/export finite element meshes viz Exodus-II file format
- Cartesian or cylindrical coordinates

Numerical Modeling Options
- TruVOF – Volume-of-Fluid (VOF) method for fluid interfaces
- First and second order advection
- Sharp fluid interface tracking
- Implicit & explicit numerical options
- GMRES, point and line relaxation pressure solvers
- User-defined variables, subroutines & output
- Utilities for runtime interaction during execution

Fluid Modeling Options
- One incompressible fluid – confined or with free interfaces
- Two incompressible fluids – miscible or with sharp interfaces
- Compressible fluid – subsonic, transonic, supersonic
- Stratified fluid
- Acoustic phenomena
- Mass particles with variable density or diameter

Thermal Modeling Options
- Natural convection
- Forced convection
- Conduction in fluid & solid
- Fluid-solid heat transfer
- Heat transfer to voids from fluid/obstacles
- Distributed energy sources/sinks in fluids or solids
- Radiation
- Temperature-dependent material properties
- Orthotropic thermal conductivity

Flow Definition Options
- General boundary conditions
  - Symmetry
  - Rigid and flexible walls
  - Continuative
  - Periodic
  - Specified pressure
  - Specified velocity
  - Outflow
  - Grid overlay
  - Hydrostatic pressure
  - Volume flow rate
  - Non-linear periodic and solitary surface waves
- Restart from previous simulation
- Continuation of a simulation
- Overlay boundary conditions
- Change mesh and modeling options
- Change model parameters

Flow Type Options
- Internal, external & free-surface flows
- 3D, 2D & 1D problems
- Transient flows
- Inviscid, viscous laminar & turbulent flows
- Hybrid shallow water/3D flow models
- Non-interactive reference frame motion
- Multiple scalar species
- Two-phase flows
- Heat transfer with phase change
- Saturated & unsaturated porous media

“IT is FLOW-3D’s inherent simplicity that lends itself to use in real-world problem solving. Rather than spending large amounts of time pre-processing (i.e., setting problems up), users can spend their time applying the results of their work.”

-John Richardson, Blue Hill Hydraulics.
COMMUNICATING YOUR RESULTS

FLOW-3D fully supports users in the water & environmental industry with specialized output for communicating key model results. FLOW-3D outputs data graphically in 1-D, 2-D and 3-D views and provides numerical data for export to other analysis packages. Available data for point gauges and color field plots includes:

- Flow tracers to track fluid distribution and mixing
- Fluid residence time
- Free surface elevation
- Fluid depth
- Froude number
- Turbulent intensity, dynamic turbulent viscosity, turbulent kinetic energy, turbulent energy dissipation rate, and turbulent mixing length scale
- Distance traveled by fluid packets
- Vorticity
- Depth-averaged velocity
- Velocity at an offset from the bottom
- Hydraulic energy and total hydraulic head
- Shear stress on surfaces
- Entrained air concentration
- Suspended sediment concentration
- Change in bed elevation due to erosion and deposition
- Contaminant concentrations, including local mixture density
Substantial increases in performance and scaling can be achieved with **FLOW-3D/MP**.

**FLOW-3D/MP** enables engineers to take advantage of the scaling potential of high-performance computing on clusters to simulate very large domains or long real-time events.

Visit our website for more information, including performance benchmarks using typical water and environmental simulations.
A variety of technical support packages are available to streamline your modeling process. Flow Science’s support staff is comprised of engineers with industry experience who understand the needs and problems facing users in competitive professional environments. Flow Science prides itself on offering timely and courteous support from our expert applications engineers for the water & environmental industry.

**Training**

Flow Science offers comprehensive **FLOW-3D** training classes for customers in the water and environmental industry in Santa Fe, New Mexico. Classes provide attendees a solid understanding of the software and hands-on experience solving relevant problems. Classes may be combined with specific project consultations when deadlines demand fast results. Existing and new users, as well as those interested in evaluating the software, are invited to attend.

“I wanted to thank you for all your support during the FLOW-3D training, particularly during the individual consultation session. Your willingness to assist in developing my application is really appreciated. Please extend my thanks to all at Flow Science for an extremely well-delivered training course.”

Juan A. Gonzalez-Castro, Chief Consulting Engineer, SFWMD, Operations and Hydro Data Management Division

In 1963, while at the Los Alamos National Laboratory, Dr. C. W. “Tony” Hirt pioneered several landmark fluid dynamics methods, stability enhancing procedures and a unique free surface tracking technique – the “Volume of Fluid” or VOF method. In 1980, Dr. Hirt left LANL to form Flow Science, Inc., with the mission to develop a new generation of fluid dynamics modeling capabilities for industrial and scientific applications.

Flow Science now supports a worldwide customer base of commercial, academic and government users. Our staff of scientists and engineers constantly strives to make innovative and useful improvements to our product suite. We take pride in the level of customer support we provide. In 2010, Flow Science celebrated its 30th year of improving the world through accurate flow modeling.

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